Characterization of Potential Adverse Health Effects Associated with Consuming Fish from

Fosdic Lake

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Tarrant County, Texas

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INTRODUCTION

Description of Fosdic Lake and History of the Extant Possession Ban

Fosdic Lake is a six- to- seven-surface-acre impoundment of an unnamed tributary of the West Fork Trinity River used primarily to collect storm-water runoff.[1] Fosdic Lake is in Oakland Lake Park near the southwest corner of East Freeway (Interstate 30) and East Loop 820 off Oakland Boulevard. The pond collects urban runoff from a 0.43 square-mile watershed consisting primarily of a heavily populated older residential neighborhood near downtown Fort Worth, TX.[1, 2] Fort Worth, the county seat of Tarrant County – a part of the 12-county Dallas-Fort Worth Metropolitan Statistical Area (the DFWMSA, called simply "the Metroplex" by many), is the largest MSA in Texas and the 4th largest in the U.S. In the 2000 decennial census, the U.S. census bureau reported the population of the DFWMSA as 5,161,544 persons.[3] By 2006, that population had swelled to more than six million people.[3]

The Texas Parks and Wildlife Department (TPWD) likely originally stocked Fosdic Lake between 1990 and 1994 with fingerling channel catfish as part of a TPWD urban fisheries program. In the summer of 1994, the City of Fort Worth sampled fish from Fosdic Lake for a number of environmentally deposited toxicants.[4] Having observed chlordane and other contaminants in the analytical results from those fish, the City of Fort Worth requested that the former Texas Department of Health (TDH; presently the Department of State Health Services – DSHS) conduct additional sampling of Fosdic Lake. Responding to the City of Fort Worth's request, the TDH collected seven fish samples from Fosdic Lake (largemouth bass, white crappie, and channel catfish). The TDH analytical laboratory reported the 1994 Fosdic Lake samples to contain chlordane, DDE, dieldrin, and Aroclor® compounds.(PCBs).[5] Some contaminant concentrations exceeded guidelines then used by the state's health department to protect human health from potential adverse health outcomes from consumption of such compounds in contaminated fish. On April 5, 1995, in response to the 1994 laboratory findings, Dr. David Smith, at that time the Commissioner of Health for the state of Texas, issued Aquatic Life Order #10 (AL-10), an executive order that prohibited possession of any species of fish from Fosdic Lake.[6]

In 2000, the City of Fort Worth collected five largemouth bass to reanalyze contaminants in fish from Fosdic Lake. The TDH survey team assisted the city of Fort Worth in 2001, collecting five additional largemouth bass for the reassessment of conditions in Fosdic Lake. The TDH laboratory analyzed all fish collected in 2000 and 2001. Using the analytical results from the ten largemouth bass, state risk assessors reevaluated contaminants in fish from Fosdic Lake to determine whether consumption of fish from this reservoir contained contaminants at levels that could pose a risk of adverse health outcomes in people who ate fish from Fosdic Lake. The 2000-2001 (released in 2002) results revealed no toxicants in largemouth bass that should have increased the potential risk of toxicity to humans who consumed those fish from Fosdic Lake. However, risk managers; determining that generalizing from one species to all other species in the pond was inappropriate, elected – in the interest of public health – to retain AL-10, anticipating an early return to Fosdic Lake to collect a range of species for evaluation.[7] As of the present report, AL-10 remains in force at Fosdic Lake.

For the present study, the DSHS Seafood and Aquatic Life Group (SALG; formerly the Seafood Safety Division Survey Branch) survey team collaborated with the Total Maximum Daily Load (TMDL) Program of the Texas Commission on Environmental Quality (TCEQ) to reassess fish from Fosdic Lake for environmental toxicants, consumption of which fish could potentially pose a risk to human health. This report discusses the results, reports conclusions based on the survey, addresses implications to public health, if any, of consumption of contaminated fish from Fosdic Lake, recommends actions related to public health, supplies the TMDL Program with data, and fulfills the terms of the cooperative agreement with the TCEQ's TMDL Program.

The Total Maximum Daily Load Program (TMDL Program) at the Texas Commission on Environmental Quality (TCEQ) and the Influence of the Department of State Health Services (DSHS) Consumption Advisories or Possession Bans on the TMDL Program.

The TCEQ enforces federal and state laws that promote judicious use of water bodies under states' jurisdiction and that protect state-controlled water bodies from pollution. Under the federal Clean Water Act, Section 303(d),[8] all states must establish a "total maximum daily load" (TMDL) for each pollutant contributing to the impairment of one or more designated uses for a water body. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and non-point sources, and including a margin of safety and accounting for seasonal variation in water quality parameters, that will insure the water body as suitable for all its designated purposes. States, territories, and tribes define the uses for a specific water body (e.g., drinking water, contact recreation, aquatic life support, including fish consumption), along with the scientific criteria used to support each specified use. Section 303 of the Clean Water Act, a federal law that promulgates water quality standards, orders the establishment of TMDLs and implementation plans.[8] Under the Act, fish consumption is a recognized use for many reservoirs. A water body is, thus, impaired if contaminants in fish from the water body cause those fish to be unfit for consumption. Although a water body and its aquatic life may spontaneously clear toxicants with removal of source(s) of the contaminant(s), it is often necessary to institute some form of remediation to assure the water body regains its former state. The TMDL Program seeks to do just that. Thus, issuance by the DSHS of a possession ban on a water body containing environmentally contaminated fish or consumption advice for such fish,[9] the TMDL Program may place the water body on a draft 303(d) List.[10] When a water body is placed on the draft 303(d) list, the TMDL Program prepares TMDLs for contaminants listed in the advisory or in the possession ban if concentrations of those contaminants reach significance designated by the TMDL Program. Once the TCEQ accepts a TMDL and the United States Environmental Protection Agency (USEPA) approves it, the TMDL Program prepares an Implementation Plan – a "remediation" plan – aimed at restoring fish in the water body to their former state of health. Upon implementation, these plans facilitate rehabilitation of the water body. Successful remediation should result in return of the water body to conditions compatible with all its stated uses, including that of fish consumption, which – in the case of Fosdic Lake – would consist of removal of the possession ban and/or any consumption advice in place for fish from the lake. When the DSHS lifts a possession ban, people may once again keep and eat fish from that water body. Removal of consumption advice implies the same endpoint: that former stated limitations on consumption is no longer necessary. One requirement of a TMDL implementation plan for water bodies on a state's 303(d) list might be the periodic reassessment of contaminant levels in fish. For Fosdic Lake, which is a part of a TMDL Implementation Plan for the "Fort Worth Lakes", the TMDL Program does specify such periodic reassessments.

Subsistence Fishing at Fosdic Lake

The USEPA suggests that, along with ethnic characteristics and cultural practices of an area's population, the poverty rate could contribute to determination of the rate of subsistence fishing in an area.[10] The DSHS SALG agrees with the USEPA that it is important to consider subsistence fishing to occur at any water body because subsistence fishers (as well as recreational anglers and certain tribal and ethnic groups) usually consume more locally caught fish than does the general population. These groups may harvest fish or shellfish from the same water body over many years to supplement caloric and protein intake. Should local water bodies contain chemically contaminated fish or shellfish, people who repeatedly eat fish from the same source or who eat large quantities of fish from the waters at each meal, could increase their risk of adverse health effects. The USEPA suggests that states assume at least 10% of licensed fishers in any area to be subsistence fishers. Fosdic Lake is in a community park near large, old neighborhoods. Recreational fishing was once encouraged, as shown by historical stocking practices. Subsistence fishing – while not explicitly documented by the DSHS – likely occurs at Fosdic Lake. The DSHS assumes, in agreement with the USEPA, that the rate of subsistence fishing is similar to the USEPA's estimate.[10]

METHODS

Fish Tissue Collection and Analysis

The DSHS Seafood and Aquatic Life Group (SALG) collects and analyzes edible fish from the state's public waters to evaluate potential risks to the health of people consuming contaminated fish or shellfish. Fish tissue sampling follows standard operating procedures from the DSHS *Seafood and Aquatic Life Group Survey Team Standard Operating Procedures and Quality Control/Assurance Manual.*[11] The SALG bases its sampling and analysis protocols, in part, on procedures recommended by the USEPA in that agency's *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1.*[12] Advice and direction are also received from the legislatively mandated *State of Texas Toxic Substances Coordinating Committee (TSCC) Fish Sampling Advisory Subcommittee (FSAS).*[13] Samples usually represent species, trophic levels, and legal-sized specimens available for consumption from a water body. When practical, the DSHS collects samples from two or more sites within a water body to better characterize geographical distributions of contaminants.

Description of the Fosdic Lake 2005 Sample Set

Between October 31 and November 3, 2005, the DSHS SALG survey team collected 10 fish from Fosdic Lake (9 largemouth bass and 1 common carp; Table 1). Although the survey team had hoped to collect a variety of species from Fosdic Lake, the team observed limited species diversity in Fosdic Lake. Apparently, suspension of stocking activities in late 1994, the poor condition of the habitat and fishing pressure has eliminated – over many years – the channel catfish so commonly observed in urban fisheries stocked for fishing. The survey team observed only largemouth bass, common carp, and sunfish. Additionally, from this sampling trip and from trips to the other two lakes on the "Fort Worth Lakes" TMDL resulted in a sample consisting of approximately 80 to 100% largemouth bass. The consistency of these observations and collection patterns leads one to believe that the samples represent the limited range of species available for harvest. According to the survey crew, sunfish likely make up the largest proportion of the fish population in such areas.

Because Fosdic Lake is a small water body (6-7 surface-acres), the DSHS SALG did not select sample sites to provide spatial coverage of the study area; rather, the group utilized the entire lake as a single "site" (Figure 1). The SALG targeted species for collection from Fosdic Lake through fish-tissue sampling protocols developed over many years by the SALG and its legacy group, the TDH SSD. Species collected represent distinct ecological groups (i.e. predators and bottom-dwellers) that have some potential to bio-accumulate chemical contaminants, have a wide geographic distribution, are of local recreational fishing value, and/or that anglers and their families commonly consume.

During each day of sampling, staff set gill nets in late afternoon and fished those overnight, collecting samples from the nets early the following morning. Gill nets were set to maximize available cover and habitat in the lake. SALG staff stored captured fish retrieved from the nets on wet ice until processed. The staff returned to the lake any remaining live fish culled from the catch. Staff also properly disposed of fish found dead in the gill nets.

The SALG utilized a boat-mounted electrofisher to collect fish. SALG staff conducted electrofishing activities during daylight hours, using pulsed direct current (Smith Root 7.5 GPP electrofishing system settings: 4.0-6.0 amps, 60 pulses per second [pps], low range 360 volts, 80% duty cycle) to stun fish that crossed the electric field in the water in front of the boat. Staff used dip nets over the bow of the boat to retrieve stunned fish, netting only fish pre-selected as target samples. Staff immediately stored retrieved samples on wet ice in large coolers to ensure interim preservation.

SALG staff processed fish on site at Fosdic Lake, weighing each sample to the nearest gram on an electronic scale and measuring total length (tip of nose to tip of tail fin) to the nearest millimeter. The survey team then used a cutting board covered with aluminum foil and a fillet knife to prepare one or two skin-off fillets from each fish. Foil was changed and the filleting knife cleaned with distilled water after processing each sample. The team wrapped each fillet in two layers of aluminum foil, placed the samples in new pre-labeled plastic freezer bags, and stored them on wet ice in an insulated chest. At the end of the sampling trip, the DSHS SALG survey team transported the samples on wet ice to their Austin, TX, headquarters, where the samples were stored temporarily at -5° Fahrenheit (-20° Celsius) in a locked freezer.

Analytical Laboratory Information

During the week following sample collection, the DSHS SALG survey team shipped the samples overnight by common carrier, delivering the samples (skin-off fillets of 9 largemouth bass and one common carp) frozen on common wet ice to the Geochemical and Environmental Research (GERG) Laboratory at Texas A&M University, College Station, TX, for contaminant analysis.

Upon receipt of the samples the laboratory notified the DSHS SALG, recorded the DSHS sample number, and the condition, upon receipt, of each tissue sample.

Utilizing USEPA-sanctioned methodology, the laboratory analyzed the 10 samples for common inorganic and organic contaminants, including seven metals – total arsenic (the laboratory analyzed the samples for total (inorganic arsenic + organic arsenic = total) arsenic). Although proportions of organic and inorganic arsenic may differ among species, under different water conditions, and, perhaps, with other variables, the literature suggests that well over 90% of arsenic in fish is likely organic arsenic – a form of arsenic that is virtually non-toxic to humans.[14] The SALG, taking a relatively conservative approach, estimates 10% of the total arsenic in any fish as inorganic arsenic, deriving estimates of inorganic arsenic concentrations by multiplying reported total arsenic concentration/fish by a factor of 0.1.[15] The laboratory also reported the results of analysis for cadmium, copper, lead, selenium, zinc, and total mercury. Although the literature suggests that most, if not all, mercury in fish is organic methylmercury, technical and fiscal restraints make measurement of total mercury the test most utilized for fish tissue, as suggested by the USEPA. In its risk characterizations, DSHS compares mercury concentrations in tissues to a comparison value derived from the ATSDR's minimal risk level (MRL) for methylmercury. In these risk characterizations, the DSHS may also interchangeably utilize the terms "mercury", "methylmercury", or "organic mercury" to refer to methylmercury in fish).

The laboratory analyzed the 10 fish for 34 pesticides representing organophosphates, organochlorines, carbamates, and miscellaneous pesticides. The laboratory also analyzed the tissue samples for PCBs. Finally, two of the 10 submitted samples (one largemouth bass and one common carp) for measurement of panels of semivolatile organic compounds (SVOCs) and volatile organic compounds (VOCs).

PCB Congener Analysis

The GERG laboratory reports the presence and concentrations of 209 PCB congeners using detection limits that are, typically, around 1 µg/kg. Although only about 130 congeners existed in mixtures commonly used in the U.S. (Aroclors), it may be useful to have measured all 209 congeners to examine the effects of "weathering" on the PCB mixture presumed originally disseminated

Despite EPA's suggestion that states utilize PCB congener analysis, the toxicity literature does not reflect this state-of-the-art laboratory science, making it somewhat difficult for states to determine the toxicity of congeners identified in fish tissues. To address this dilemma, DSHS SALG risk assessors adopted recommendations from the National Oceanic and Atmospheric Administration (NOAA),[16] from McFarland and Clarke,[17] and from the USEPA's guidance documents [13,18] to assess PCBs in fish tissues. Those investigators chose each congener for its likelihood of occurrence in fish, the likelihood of significant toxicity – based on structure-activity relationships, – and for the relative environmental abundance of the congener.[16, 17] Assessors at the DSHS SALG sum concentrations of 43 PCB congeners to derive a "total" PCB concentration in each fish. DSHS SALG risk assessors use the "total" PCB congeners in each sample to obtain an average concentration across samples. DSHS SALG assessors then use that mean PCB concentration to characterize risk from PCB contamination in fish from a given water body, so determining the possibility of adverse health outcomes from consuming PCBs in fish from the water body in question.

The use of only a few PCB congeners to determine "total PCBs" could underestimate PCB concentrations in fish tissue. Nonetheless, this method complies with expert recommendations on evaluation of PCB toxicity. SALG risk assessors compared average PCB concentrations with information in the USEPA's Integrated Risk Information System (IRIS) database.[19] IRIS currently contains information on the toxic effects, reference doses (RfDs), cancer potency factors) (CPFs, and other information for five Aroclor mixtures: Aroclor 1016, 1242, 1248, 1254, and 1260 (not all information is available for all the mixtures) as well as combined PCBs.[19] Systemic toxicity estimates in this document reflect comparisons with the RfD for Aroclor 1254, for instance, because IRIS contains an RfD for Aroclor 1254 but not for Aroclor 1260. As of yet, IRIS does not contain toxicity information on individual PCB congeners. Risk assessors may not have been able to determine which Aroclor mixture was originally present, or, indeed, if the PCBs observed even originated from Aroclor mixes – U.S. companies used PCB mixtures imported from other countries and airplanes and ships from foreign countries entered U.S. waters. Those vessels could have discharged foreign-made PCB mixtures into U.S. portal waters.

Statistical Analysis

SALG risk assessors employed SPSS® statistical software, version 13.0 installed on IBM-compatible microcomputers (Dell, Inc) to generate descriptive statistics (mean, standard deviation, median, range, and minimum and maximum concentrations) on all measured compounds in largemouth bass. Since there was only one common carp, descriptive statistics were not necessary for that sample. However, the DSHS SALG risk assessors used SPSS to generate descriptive statistics on the combined sample. DSHS SALG used the analytical data to assess potential adverse human health outcomes from consuming fish from Fosdic Lake.[20] SALG risk assessors utilized ½ the detection limit for all analytes not detected (ND) or listed as an estimated concentration (J-value – standard laboratory nomenclature for an analyte concentration the value of which may not be accurate) to compute descriptive statistics. DSHS SALG risk assessors imported previously edited Excel data files into SPSS® to generate descriptive statistics for each measured analyte in each fish species. SALG used the descriptive statistics to generate the present report. SALG protocols do not require hypothesis testing. Nevertheless, when data are of sufficient quantity and quality, and, should it be necessary, the SALG utilizes SPSS® software to determine significant differences in contaminant concentrations among species and/or collection sites. The SALG employed Microsoft Excel® spreadsheets to generate figures, compute health-based assessment comparison values (HAC_{nonca}) for contaminants, and to calculate hazard quotients (HQ), hazard indices (HI), cancer risk probabilities, and/or meal consumption limits for fish from Fosdic Lake.[21] When lead data are of sufficient quality, concentration, and interest, the SALG utilizes the USEPA's Interactive Environmental Uptake Bio-Kinetic (IEUBK) model to determine whether, if consumed, certain concentrations of lead in fish could cause children's blood lead (PbB) level to exceed 10 micrograms/deciliter. A blood lead greater than 10 mcg/dL is the concentration designated by the Centers for Disease Control and Prevention to be of concern to the health of children exposed to environmental lead.[22]

Derivation and Application of Health-Based Assessment Comparison Values (HACs)

The effects of exposure to any hazardous substance depend on the dose, the duration of exposure, the manner in which one is exposed, one's personal traits and habits, and whether other chemicals are present.[23] People who regularly consume contaminated fish or shellfish conceivably suffer repeated exposures to relatively low concentrations of contaminants over extended times. Such exposures are unlikely to result in acute toxicity but may increase risk of subtle, chronic, and/or delayed adverse health effects that include cancer, benign tumors, birth defects, infertility, blood disorders, brain damage, peripheral nerve damage, lung disease, and kidney disease, to name but a few.[23] Presuming people to eat a diet of diverse fish or shellfish from a water body if species variety is available, the DSHS routinely collapses data across species and sampling sites to evaluate mean contaminant concentrations of toxicants in all samples. This approach intuitively reflects consumers' likely exposure over time to contaminants in fish or shellfish from a water body, but may not reflect reality at a specific water body. The agency thus reserves the right to examine risks associated with ingestion of individual species of fish or shellfish from separate collection sites or at higher concentrations (e.g., the upper 95 percent confidence limit on the mean concentration. The SALG utilizes Monte Carlo simulations (software developed by RA Beauchamp[24]) to derive confidence intervals on theoretical distributions. The DSHS evaluates contaminants in fish by comparing the mean, and – when appropriate – the 95% upper confidence limit on the mean concentration of a contaminant to its health-based assessment comparison (HAC) value (measured in milligrams of contaminant per kilogram of edible tissue – mg/kg) derived for non-cancer or cancer endpoints. To derive HAC values for systemic (HAC_{nonca}) effects, the department assumes a standard adult weighs 70 kilograms and that adults consume 30 grams of edible tissue per day (about one 8-ounce meal per week). The DSHS uses EPA's oral reference doses (RfDs)[25] or the Agency for Toxic Substances and Disease Registry's (ATSDR) chronic oral minimal risk levels (MRLs)[26] to generate HAC values used in evaluating systemic (noncancerous) adverse health effects. The USEPA defines an RfD as

> *An estimate of a daily oral exposure for a given duration to the human population (including susceptible subgroups) that is likely to be without an appreciable risk of adverse health effects over a lifetime.*[27]

EPA also states that the RfD

> … *is derived from a BMDL* (benchmark dose lower confidence limit)*, a NOAEL* (no observed adverse effect level)*, a LOAEL* (lowest observed adverse effect level)*, or another suitable point of departure, with uncertainty/variability factors applied to reflect limitations of the data used. [Durations include acute, short-term, subchronic, and chronic and are defined individually in this glossary]*

and

> *RfDs are generally reserved for health effects thought to have a threshold or a low dose limit for producing effects.*[27]

The ATSDR uses a similar technique to derive MRLs.[26] The DSHS compares the estimated daily dose (mg/kg/day) – derived from the mean of the measured concentrations of a contaminant – to the contaminant's RfD or MRL, using hazard quotient (HQ) methodology as suggested by the USEPA.

A HQ, defined by the EPA, *is*

> *…the ratio of the estimated exposure dose of a contaminant (mg/kg/day) to the contaminant's RfD or MRL (mg/kg/day).*[28]

Note that a linear increase in the hazard quotients for a site or species usually does *not* represent a linear increase in the likelihood or severity of systemic adverse effects (i.e., a substance having an HQ of 2 is not twice as toxic as if the substance had an HQ of 1.0. Similarly, a substance with a HQ of 4 does not imply that adverse events will be four times more likely than a HQ of 1.0). As stated by the EPA, a HQ (or an HI) of less than 1.0 "is no cause for concern, whereas an HQ (or HI) greater than 1.0 should indicate some cause for concern." Risk managers at DSHS utilize a HQ of 1.0 as a "jumping-off point"- not for decisions on the possibility of adverse systemic health outcomes – but as a point of departure for management decisions, assuming, in a manner similar to EPA decisions, that fish or shellfish having a hazard quotient smaller than 1.0 are unlikely to cause concern. Since the chronic oral RfD derived by the USEPA represents chronic consumption, eating fish with a toxicant-to-RfD ratio (the HQ) of less than 1.0 is not likely to result in adverse health effects, whereas routine consumption of fish where the HQ for a specific chemical exceeds 1.0 represents a qualitatively unacceptable increase in the likelihood of systemic adverse health outcomes.

Although DSHS preferentially utilizes a reference dose (RfD) derived by federal scientists for each contaminant, should no RfD be available for a specific contaminant, the USEPA advises risk assessors to consider using a reference dose determined for a contaminant of similar molecular structure, or mode or mechanism of action.

In the past, when DSHS had access only to Aroclor measurements, the agency did not attempt to determine the dioxin equivalent toxicity of coplanar PCBs found in fish. The SALG recently adopted PCB congener analysis, as is suggested by the USEPA. This change in methodology allows the agency to identify coplanar or dioxin-like PCBs and to apply toxicity equivalency factors (TEFs) to PCBs in fish should this option become a priority.

The DSHS calculates its HAC values from constants (RfDs, MRLs) derived by federal agencies from the peer-reviewed literature (those federal agencies routinely re-examine the literature for changes in understanding of toxicity or other variables used in federal risk assessment activities).The federally-derived values incorporate built-in margins of safety called "uncertainty factors" or "safety factors" as mentioned in EPA reference materials.[27] To develop oral RfDs and MRLs, federal scientists review the extant literature to determine NOAELs, LOAELs, or BMDs from experimental studies, usually in research animals such as rats or monkeys. The agencies then utilize uncertainty factors to minimize potential systemic adverse health effects in people exposed through consumption of contaminated materials, accounting for conditions that may have not have been elicited by experimental studies such as extrapolation from animals to humans (interspecies variability), intra-human variability, use of a subchronic study rather than a chronic study to determine the NOAEL, LOAEL, or BMD, and database insufficiencies.[25] Vulnerable groups – women who are pregnant or lactating, women who may become pregnant, the elderly, infants, children, people with chronic illnesses, those with already-compromised immune systems, or those who consume exceptionally large servings – called "sensitivities" by the EPA, also receive special consideration in calculations of the RfD.[27, 29]

The DSHS calculates cancer-risk comparison values (HAC_{ca}) from the EPA's chemical-specific cancer potency factors (CPFs) – also known as slope factors (SFs) – derived through mathematical modeling of carcinogenicity studies. For carcinogenic outcomes, the DSHS calculates a theoretical lifetime excess risk of cancer for specific exposure scenarios for carcinogens, using a standard 70-kg body weight and assuming an adult consumes 30 grams of edible tissue per day. The SALG risk assessors incorporate two additional factors into determinations of theoretical lifetime excess cancer risk: (1) an acceptable lifetime risk level (ARL) [27] of one excess cancer case in 10,000 persons whose average daily exposure is equal and (2) daily exposure for 30 years. Comparison values used to assess the probability of cancer, thus, do not contain "uncertainty" factors as such. However, conclusions drawn from those probability determinations infer substantial safety margins for all people by virtue of the models utilized to derive the slope factors (cancer potency factors).

Because the calculated comparison values (HAC_{nonca} and HAC_{ca}) are quite conservative, adverse systemic or carcinogenic health effects are unlikely to occur, even if exposures are consistently greater or for longer times than those used for comparison values. Moreover, comparison values for adverse health effects (systemic or carcinogenic) do not represent sharp dividing lines (bright-line divisions) between safe and unsafe exposures. The perceived strict demarcation between acceptable and unacceptable exposures or risks is primarily a tool to assist risk managers to make decisions that ensure protection of the public's health. For instance, the DSHS considers it unacceptable when consumption of four or fewer meals per month of contaminated fish or shellfish would result in exposure to contaminant(s) in excess of a HAC value or other measure of risk even though most such exposures are unlikely to result in adverse health effects. The department further advises people who wish to minimize exposure to contaminants in fish or shellfish to eat a variety of fish and/or shellfish and to limit consumption of those species most likely to contain toxic contaminants. DSHS aims to protect vulnerable subpopulations with its consumption advice. The DSHS assumes that advice protective of vulnerable subgroups will also minimize the impact to the general population of consuming contaminated fish or shellfish.

Children's Health Considerations

The DSHS recognizes that fetuses, infants, and children may be uniquely susceptible to the effects of toxic chemicals and suggests that exceptional susceptibilities demand special attention.[30, 31] Windows of special vulnerability; known as "critical developmental periods," exist during development. Critical periods occur particularly during early gestation (weeks 0 through 8), but can occur at any time during pregnancy, infancy, childhood, or adolescence – indeed, at any time during development – times when toxicants can impair or alter the structure or function of susceptible systems.[32] Unique early sensitivities may exist because organs and body systems are structurally or functionally immature – even at birth – continuing to develop throughout infancy, childhood, and adolescence. Developmental variables may influence the mechanisms or rates of absorption, metabolism, storage, or excretion of toxicants, any of which factors could alter the concentration of biologically effective toxicant at the target organ(s) or that could modulate target organ response to the toxicant. Children's exposures to toxicants may be more extensive than adults' exposures because, in proportion to their body weights, children consume more food and liquids than do adults do, another factor that might alter the concentration of toxicant at the target. Infants can ingest toxicants through breast milk – an exposure pathway that often goes unrecognized (nonetheless, the advantages of breastfeeding outweigh the probability of significant exposure to infants through breast milk. Women are encouraged to continue breastfeeding and to limit exposure of their infants by limiting intake of the contaminated foodstuff). Children may experience effects at a lower exposure dose than might adults because children's organs may be more sensitive to the effects of toxicants. Stated differently, children's systems could respond more extensively or with greater severity to a given dose than would an adult organ exposed to an equivalent dose of a toxicant. Children could be more prone to developing certain cancers from chemical exposures than are adults.[33] In any case, if a chemical – or a class of chemicals – is observed to be – or is thought to be – more toxic to the fetus, infants, or children than to adults, the constants (e.g., RfD, MRL, or CPF) are usually further modified to assure protection of the immature system's potentially greater susceptibility.[25] Additionally, in accordance with the ATSDR's *Child Health Initiative*[34] and the EPA's *National Agenda to Protect Children's Health from Environmental Threats,*[35] the DSHS further seeks to protect children from the possible negative effects of toxicants in fish by suggesting that this potentially sensitive subgroup consume smaller quantities of contaminated fish or shellfish than adults consume. Thus, DSHS recommends that children weighing 35 kg or less and/or who are 11 years of age or younger limit exposure to contaminants in fish or shellfish by eating no more than four ounces per meal of the contaminated species. The DSHS also recommends that consumers spread these meals over time. For instance, if the DSHS issues consumption advice that suggests consumption of no more than two meals per month of a contaminated species, those children should eat no more than 24 meals of the contaminated fish or shellfish per year and, ideally, should not eat such fish or shellfish more than twice per month.

RESULTS

Laboratory Analytical Results

The GERG laboratory submitted electronic copies of the results of laboratory analyses of chemicals in the Fosdic samples to the DSHS in the autumn of 2006. The laboratory analyzed 10 fish (9 largemouth bass; 1 common carp) for seven metallic or metalloid constituents: total arsenic, cadmium, copper, total mercury, lead, selenium, zinc, and for pesticides and PCBs. The laboratory also analyzed two of the samples for semivolatile organic compounds (SVOCs) and volatile organic compounds (VOCs). For the reader's convenience, Table 1 presents the sample number, species collected and the length and weight of each sample.

Inorganic Contaminants

Arsenic, Cadmium, Copper, Lead, Mercury, Selenium, and Zinc

Small quantities of arsenic were present in all fish from Fosdic Lake (Table 2a); the mean total arsenic concentration in the ten fish was 0.064 ± 0.026 mg/kg. Inorganic arsenic in the nine largemouth bass and the common carp were estimated from total arsenic as approximately 0.006 mg/kg (calculated as 1/10 the concentration of total arsenic). Nine of 10 fish contained cadmium, but only at levels below the laboratory's detection limit (BDL). One fish, a largemouth bass, contained lead at an estimated concentration (J-value – a concentration lower than the laboratory's detection limit, abbreviated as "BDL" in Table 2b. Copper, selenium, and zinc (all of which are essential nutrients in humans and some other organisms) were present at commonly observed levels in all 10 fish from Fosdic Lake (Table 2b; 2c). Nine of nine largemouth bass contained mercury, the average concentration of which was 0.253±0.169 mg/kg. The single common carp in the sample also contained mercury at a level below the laboratory's detection limit (BDL) (Table 2c).

Organic Contaminants

Pesticides

One largemouth bass contained 4,4'-DDT at a concentration below the laboratory's detection limit for 4,4'-DDT (BDL). Nine samples contained no detectable 4,4'-DDT. Four largemouth bass contained estimated (J-values) 4,4'-DDD (levels were below the laboratory's detection limit, BDL). Five largemouth bass and the common carp contained no detectable 4,4'-DDD. Five largemouth bass contained measurable 4,4'-DDE (mean 0.007±0.005 mg/kg), while four bass contained estimated 4,4'-DDE (concentrations were BDL). The common carp contained 0.043 mg/kg of 4,4'-DDE. Three largemouth bass contained measurable quantities of chlordane (Table 3); six largemouth bass contained estimated quantities of chlordane (BDL). The common carp contained 0.063 mg/kg of chlordane. One largemouth bass contained a low, estimated concentration of methoxychlor (J-value; BDL). All other samples contained no detectable concentrations of methoxychlor (data not shown). The laboratory reported no other quantifiable pesticides in fish from Fosdic Lake.

PCBs

The DSHS SALG recently revised its methodology for analyzing fish tissue PCBs from analyzing tissues for Aroclors® to measuring the tissues for congeners of PCBs. Thus, the present study marks the first time the DSHS has analyzed Fosdic Lake fish tissues for PCB congeners. In the previous survey of Fosdic Lake, conducted in 2000 and 2001 (reported in 2002), no PCBs occurred at detectable levels (MDL=0.040 mg/kg) in fish from Fosdic Lake. However, Aroclor analysis is much less sensitive than is congener analysis. Therefore, PCBs at concentrations lower than the laboratory's detection limit for Aroclors (0.040 mg/kg) could well have been present in fish collected in 2000 and 2001. Congener analysis is particularly sensitive (MDL circa 0.001 mg/kg), so it is easy to see that detection of PCBs in the 2005 samples does not imply PCBs to be absent in fish collected in 2000-2001. Instead, the 2005 data only confirm the greater sensitivity of congener analysis. PCBs in fish collected in 2005 from Fosdic Lake should accurately represent PCB concentrations in fish at the time of collection. Although inter-year comparisons of absolute PCB levels s are inappropriate due to methodological changes, the DSHS SALG is confident that the results of the present survey accurately reflect concentrations of PCBs present in 2005 samples from Fosdic Lake. The present results do not imply that PCBs were not present in 2000-2001 or that a new or different source of PCBs is likely. Congener analysis and the resulting mathematical manipulations used to determine total PCB concentrations in each fish and the average concentrations in various groups is also unlikely to have exaggerated concentrations in the fish collected in 2005.[19]

Using congener analysis on the 2005 samples from Fosdic Lake, the laboratory detected PCBs in all fish. The largemouth bass samples (N=9) averaged 0.031 ± 0.013 mg/kg (Table 3). PCB concentrations ranged from 0.021 to 0.059 mg/kg. The PCB concentration in the single common carp was 0.070 mg/kg, which was the highest PCB concentration reported in fish collected in 2005 from Fosdic Lake. The concentration of PCB congeners averaged across all samples (9 largemouth bass and 1 common carp) was 0.035 ± 0.017 mg/kg. The range of concentrations among all fish was 0.021 – 0.070 mg/kg (Table 3).

<u>VOCs</u>

The laboratory analyzed the chosen largemouth bass and the single common carp collected in 2005 from Fosdic Lake for common VOCs. The largemouth bass contained 0.063 mg/kg carbon disulfide (MDL = 0.039 mg/kg). The largemouth bass and the common carp both contained methylene chloride (0.438 and 0.715 mg/kg, respectively). The common carp contained 1,2,4-trichlorobenzene (0.018 mg/kg). The largemouth bass contained a trace of tetrahydrofuran (concentration below the MDL). Both samples contained naphthalene and toluene at estimated concentrations (J-values). The common carp contained chlorobenzene and 1,2,3-trichlorobenzene at concentrations below the laboratory's detection limit (BDL). The largemouth bass contained estimated quantities of 1,4 dichlorobenzene and n-propylbenzene. These compounds were not present in the laboratory's procedural blank, suggesting their presence in the samples to be "real." Nevertheless, concentrations were exceptionally low (data not shown).

<u>SVOCs</u>

The laboratory also analyzed the largemouth bass and the common carp for 123 semivolatile organic compounds (SVOCs), identifying bis (2-ethylhexyl) phthalate – a ubiquitous compound used to make plastics soft and pliable – in both samples at concentrations below the laboratory's detection limit (BDL; estimated quantities or J values). The laboratory reported no other SVOCs at estimable or detectable levels in the two fish.

DISSCUSSION

Risk Characterization

The actual risk of adverse health outcomes from exposure to toxicants based on experimental or epidemiological data is subject to the known variability of individual and population responses.

Thus, calculated risks can be orders of magnitude above or below actual risks of systemic or carcinogenic effects of the toxicants. Many factors influence this variability, including the target organ; the test species in the study; the exposure routes, doses, or periods, as well as other variations in conditions.[25] Nevertheless, the DSHS calculated a number of risk parameters for potential toxicity to humans who consume contaminated fish from Fosdic Lake. Conclusions and recommendations predicated upon the stated goal of the DSHS to protect human health follow this discussion of findings.

Characterization of Possible Systemic (Noncancerous) Adverse Health Effects Related to Consumption of Fish from Fosdic Lake

Inorganic Contaminants

The 2005 DSHS SALG survey did not reveal inorganic contaminants of toxicological interest or significance to human health in fish collected from Fosdic Lake (Tables 2a, 2b, 2c).

Organic Contaminants

Small quantities of 4,4'-DDE and chlordane (most estimated concentrations) were present in fish collected in 2005 from Fosdic Lake (Table 3). However, the hazard quotient for each pesticide was less than 1.0. Therefore, legacy pesticides such as DDE and chlordane, once an issue of concern to public health at Fosdic Lake, have decreased in fish to levels that are unlikely, when occurring alone, to cause adverse systemic health effects in humans.

All fish contained some concentration of PCBs. Two largemouth bass contained PCBs at concentrations that exceeded the $HAC_{nonca.}$ The single common carp contained 0.070 mg PCBs per kg tissue, which also exceeded the HAC_{nonca} for PCBs. (0.047 mg/kg). The HQ for PCBs in the common carp was 1.5 – indicating that PCBs in common carp from Fosdic Lake remain a problem for human health. Although one largemouth bass contained 0.059 mg/kg of PCBs, the average PCB concentration in largemouth bass (0.031 mg/kg) was below the HAC_{nonca}. At 0.024 mg/kg, the median concentration of PCBs in largemouth bass was lower than the mean, suggesting the distribution of PCBs in fish from Fosdic to be lognormal, with sample concentrations of most largemouth bass tending to the lower side of the average concentration (Table 3).

The hazard quotient for PCBs in largemouth bass was 0.67; the HQ for DDE, 0.006; that for chlordane was 0.008. These hazard quotients again indicate no public health issues for PCBs, DDE, or chlordane in largemouth bass from Fosdic Lake.

The hazard quotient for PCBs in the single common carp analyzed in 2005 was 1.5. A HQ greater than 1.0 suggests consumption of a species should be limited. In this case, consumption of common carp could still cause human health problems, meaning that consumption of common carp should be limited although these conclusions could be considered tenuous because only one common carp was analyzed. Although one purpose of the present study was to collect a variety of species, for analysis, including common carp, a target species for studies of concentration and accumulation, the survey team was unable to locate a sufficient number of common carp for collection. Largemouth bass, also a target species for toxicity and accumulation studies, were plentiful. The team also identified many sunfish, but do not typically target sunfish species for these projects because sunfish are small, short-lived fish that seldom concentrate, accumulate, or magnify toxicants.[36]

The hazard quotient for PCBs in all ten fish was 0.75 – primarily because the HQ's for 4,4'-DDE and chlordane were so low as to dilute the effect of PCBs. This finding suggests that a diet of fish from Fosdic Lake consisting mostly of largemouth bass with only an occasional common carp (for instance 9 largemouth bass to 1 common carp) would allow consumption of about 1 meal per week of fish from Fosdic Lake. The HI for all three pollutants in both species of fish was 0.77, indicating, again, that the major portion of the toxicity from the combined species from Fosdic Lake was due to the presence of the high concentration of PCBs in the common carp (data not shown). Table 4 shows the hazard quotients for PCBs in each species of fish collected in 2005 from Fosdic Lake and the HI for PCBs in all species from this lake. Based on the HQ for PCBs in common carp of 1.5, an adult could eat only 0.6 eight-ounce meals per week from Fosdic Lake. These data, stated differently, indicate that an adult weighing ±70 kg who eats ONLY common carp from Fosdic Lake should limit consumption to a maximum of two 8-ounce meals per month (1 meal every other week). Women of childbearing age who are pregnant or who may become pregnant, nursing mothers, infants, and young children may be more sensitive to the effects of PCBs. These sensitive groups should refrain from consuming common carp from Fosdic Lake.

The HQ for largemouth bass was less than 1.0 (Table 4: 0.67). Adults eating only largemouth bass from Fosdic Lake could consume approximately one eight-ounce meal/week of this species. Children under the age of 12 years or those weighing less than 35 kg should also consume fewer or smaller meals of largemouth bass (a maximum of one 4-ounce meal per week).

It is interesting to note that while in 1995, largemouth bass from Fosdic Lake contained, on average, 0.190 mg/kg of Aroclor® 1260 (hazard quotient = 4; MDL – 0.040), no largemouth bass collected in 2002 contained Aroclors® although the same methods were used to examine the tissues as were utilized in 1995. Because the team was unable to collect bottom-dwelling fish in 2002, agency risk managers concluded it premature to lift a possession ban even if replacing the ban with a consumption advisory, deciding, instead, to attempt to examine several species before taking such an action. Therefore, the aquatic life order issued in 1995 was continued (note that, based on PCB concentrations reported in the 2005 sample, had the MDL for PCBs remained at 0.04 mg/kg, analysis of many of the 2005 fish would not have contained detectable levels of PCBs (measured as Aroclors). Only one largemouth bass was tested for Aroclors in the sample that generated the 1995 ban. The PCB data from that largemouth bass (0.190 mg/kg as Aroclors®) was much higher than the mean congener concentration (0.035 mg/kg) of all fish collected in 2005

Characterization of the Possibility of Excess Lifetime Cancer Risk from Consumption of Fish from Fosdic Lake

Cancer risk is complex and is seldom a straightforward subject. Risk managers should temper their conclusions from calculated theoretical lifetime excess cancer risks by the known variability of such risks, which may be much lower or much higher than calculated, varying by orders of magnitude from the calculated risk.[25] Risk of cancer from involuntary exposure to environmental contaminants in fish from Fosdic Lake likely contributes little if any excess risk of cancer over a lifetime.[37] Nevertheless, people can reduce their risk of cancer from certain exposures by modifying behaviors. In the instance of cancer causing contaminants in fish, reducing consumption of the contaminated fish may decrease the lifetime theoretical risk of cancers if combined with other, more significant alterations in lifestyles or habits. To assist with informed decisions about the risk of exposure to carcinogens in fish or shellfish, the SALG analyzes these foods for cancer-causing chemicals, evaluates theoretical risk from exposure to contaminants in fish or shellfish, and communicates those risks to people so they can control exposure by changing their consumption habits, should they wish.

Cancer risks from eating fish from Fosdic Lake that contain only 4,4'-DDE or chlordane pose no issues for public health.

The potency of PCB mixtures to cause cancer in exposed individuals is determined using a tiered approach that depends on information available from the federal government (the USEPA's IRIS databank).[19] Three tiers of carcinogen slope factors (SFs) used to assess the impact of environmental PCBs exist. Risk assessors use the first tier, with its upper bound slope factor of 2.0 and its central tendency slope factor of 1.0, for PCBs with "high risk and persistence". Criteria for using this most restrictive slope factor include exposure via food, ingestion of sediment or soil, inhalation of dust or aerosols, dermal exposure – if an absorption factor was applied – the presence of dioxin-like, tumor-promoting, or persistent PCB congeners, and early-life exposure. Because of the potential implications of early-life exposures (see section on the unique characteristics of toxicants in children, above), including a possibly greater perinatal sensitivity, or the likelihood of interactions between hormones, enzymes, proteins, or other factors (for instance, thyroid hormone levels are depleted by PCBs; thyroid hormones are essential for normal development and growth, so it is reasonable to conclude that early-life exposure to PCBs may be associated with increased risks from depleted thyroid hormones during the developmental period). Thus, DSHS SALG risk assessors – in agreement with the USEPA – utilizes the "high risk" tier for all PCB exposure assessments because the potential for early life exposures, occurrence in food (fish), presence of persistent congeners, and other criteria are common in DSHS SALG samples.[19]

Table 3 shows PCB concentrations in fish from Fosdic Lake while Table 5 defines the calculated theoretical excess cancer risk generated from the PCB concentrations. Table 3 shows the average concentration of PCBs in all fish collected from Fosdic Lake in 2005 was 0.035±013 mg/kg. The highest concentration – reported in the only common carp collected – was 0.070 mg/kg, only 26% of the HAC_{ca} value for PCBs (0.272 mg/kg). PCBs in largemouth bass from Fosdic Lake did not approach the HAC_{ca} for PCBs (Table 3) nor do the data show an increase in the excess lifetime risk of cancer from eating common carp, largemouth bass, or both species from Fosdic Lake (Table 5). The data indicate that consumption of common carp, largemouth bass, or both species would be unlikely to increase consumers' lifetime excess cancer risk.

In summary, no fish sampled in 2005 from Fosdic Lake contained any contaminant at a concentration likely to increase the theoretical lifetime excess risk of cancer (calculations for chemicals other than PCBs are not tabled).

Characterization of Cumulative Systemic Health Effects and Cumulative Excess Lifetime Cancer Risk from Consumption of Fish from Fosdic Lake

Risk assessment guidelines from the USEPA suggest estimates of adverse systemic health effects of toxicants with similar modes or mechanisms of action or of those toxicants that attack the same target organ (e.g., the liver) may be additive. The HQs for contaminants meeting these assumptions may be summed to produce a hazard index (HI) – a number that represents the combined effects of simultaneous exposure to multiple contaminants.[38, 39] In largemouth bass from the present study, the hazard index (HI) for the three contaminants of concern (4,4'-DDE, chlordane, and PCBs) was 0.68 (data not shown). The HI for DDE, chlordane, and PCBs in the common carp sample collected in 2005 was 1.59. This HI is similar to the HQ for PCBs (1.50) in this species. Thus (1) neither DDE nor chlordane nor the combination of the two pesticides should increase the likelihood of cumulative effects from consuming common carp (data not shown) and (2) the HI of 1.59 in common carp indicates that common carp do pose a threat of systemic adverse health effects in humans who eat this species from Fosdic Lake.

Similarly, summation of calculated theoretical excess risk of cancer is useful if the agent causes cancer by any mode or mechanism (tumor initiator, tumor promoter, or enzyme inducer, for instance). The DSHS uses this general guideline to assess the likelihood of an increase in the theoretical lifetime excess cancer risk in people exposed to multiple contaminants in fish from a single water body.

The average concentration of DDE, chlordane, or PCBs in largemouth bass or common carp collected in 2005 from Fosdic Lake did not exceed the HAC_{ca} for carcinogenic effects (1.6, 1.6, or 0.272 mg/kg, respectively) in humans who regularly consume fish contaminated with these carcinogens (Table 3). The acceptable risk level (ARL) of 1 excess cancer in 10,000 people equally exposed for 30 years to all three observed carcinogens at levels similar to those in the test fish was not exceeded for consumption of common carp (risk = 1 excess cancer in 30,817 exposed persons), largemouth bass (risk = 1 excess cancer in 80,646 exposed persons), or in the risk from consuming the combined species (risk = 1 excess cancer in 64,622 exposed persons). Thus, consumption of largemouth bass and/or common carp from Fosdic Lake containing the carcinogens 4,4'-DDE, chlordane, and PCBs is not likely to increase the cumulative lifetime excess cancer risk in those who eat fish from Fosdic Lake.

CONCLUSIONS

SALG risk assessors prepare risk characterizations to determine public health hazards from consumption of fish and shellfish harvested from Texas water bodies by recreational or subsistence fishers, and – if indicated – may suggest strategies for reducing risk to the health of those who eat contaminated fish or seafood to risk managers at DSHS, including the Texas Commissioner of Health. The present study addressed the public health implications of consuming fish from Fosdic Lake – a small urban reservoir that has had a possession ban in place since 1995. Risk assessors from the SALG and the Environmental and Injury Epidemiology and Toxicology Branch (EIETB) conclude from the present characterization of potential adverse health effects of consuming contaminated fish from Fosdic Lake.

1. That the common carp sample collected in 2005 from Fosdic Lake contains PCBs at 0.070 mg/kg, a concentration 1.5 times the HAC_{nonca} for PCBs. If the common carp collected in 2005 from Fosdic Lake represents PCB concentrations in other common carp from Fosdic Lake, regularly consuming common carp from Fosdic Lake could increase the likelihood of incurring systemic adverse health effects (Tables 3 and 4). Regular consumption of common carp containing PCBs at comparable concentrations is not likely to increase the theoretical excess lifetime cancer risk. Because the possibility of adverse systemic health effects persists, risk assessors from the DSHS SALG conclude that regular consumption of common carp from Fosdic Lake continues to **pose an apparent public health hazard.**

2. That largemouth bass collected from Fosdic Lake in 2005 (nine samples) contain PCBs, but at an average concentration not likely to cause adverse health outcomes in those who consume this species from Fosdic Lake. Thus, consumption of largemouth bass from Fosdic Lake containing PCBs at concentrations similar to those observed in the 2005 samples (Tables 3, 4, and 5) likely **pose no apparent health public health hazard.**

3. That common carp and largemouth bass collected in 2005 from Fosdic Lake do not contain inorganic contaminants or pesticides, SVOCs, or VOCs at concentrations that are likely to cause systemic or carcinogenic effects in humans. These contaminants do not approach thresholds for systemic adverse health effects, nor do the concentrations result in increased risk of cancer (when applicable). Furthermore, copper, selenium, and zinc are essential nutrients for humans and other animals. Thus, consumption of these constituents in fish from Fosdic Lake likely **poses no apparent public health hazard.**

4. That calculations of cumulative effects of contaminants other than PCBs do not indicate that cumulative systemic or carcinogenic effects are likely to occur from consumption of fish from Fosdic Lake that contain more than one similarly-acting contaminant at concentrations near those found in the 2005 samples from this lake. Furthermore, those who follow consumption advice for common carp containing PCBs have little likelihood of cumulative effects (either systemic or carcinogenic) from other contaminants in largemouth bass. Thus, **no apparent public health hazard is posed** by consumption of largemouth bass containing DDE, chlordane, and PCBs at concentrations similar to those observed in this species collected from Fosdic Lake in 2005**.**

RECOMMENDATIONS

Risk managers at the DSHS have established criteria for issuing fish consumption advisories based on approaches suggested by the USEPA.[12] Confirmation through risk characterization that consumption of four or fewer meals per month (adults: eight ounces per meal; children: four ounces per meal) of fish or shellfish from a specific water body would result in exposures to toxicants in excess of DSHS health-based guidelines might lead managers to recommend consumption advice for fish or shellfish from the water body. As an alternative, the department may ban possession of fish from the affected water body. Fish or shellfish possession bans are enforceable under subchapter D of the Texas Health and Safety Code, part 436.061(a).[9] Declarations of prohibited harvesting areas are enforceable under subchapter D of the Texas Health and Safety Code, part 436.091 and 436.101. DSHS consumption advisories carry no penalties for noncompliance, but, instead, inform the public of health hazards from consuming contaminated fish or shellfish from Texas waters. With such information, the public can make informed decisions about eating contaminated fish or shellfish.. Thus, the SALG and the EIETB of DSHS conclude from this risk characterization that consuming largemouth bass from Fosdic Lake would not likely contribute to adverse health outcomes. On the other hand, the single common carp collected in 2005 from Fosdic Lake does contain PCBs at levels of concern. Based on this observation, the SALG and the EIETB recommend

1. That the DSHS rescinds AL-10 for Fosdic Lake, issuing, instead, species-specific advice that addresses the potential for adverse systemic health effects from consuming common carp from Fosdic Lake. This species of fish is likely to contain PCBs at levels that exceed the HAC_{nonca} for PCBs as illustrated in Tables 3 and 4 of this risk characterization. Table 4 suggests that people could consume approximately two meals per month of common carp (with a maximum of 24 meals per year). Tables 3 and 5 suggest that cancer is not likely at this consumption rate.

2. That, as an alternative to recommendation 1, the DSHS retain Aquatic Life Order Number 10 (AL-10), which order prohibits possession of any species of fish from Fosdic Lake. This very conservative approach to protecting public health may be justified because PCBs are capable of causing systemic, reproductive, developmental effects at lower doses and in less time than those doses associated with cancer (at the DSHS acceptable risk level of 1 excess cancer in 10,000 equally exposed persons). Elevations in the rate of cancers in exposed people are also of genuine concern.

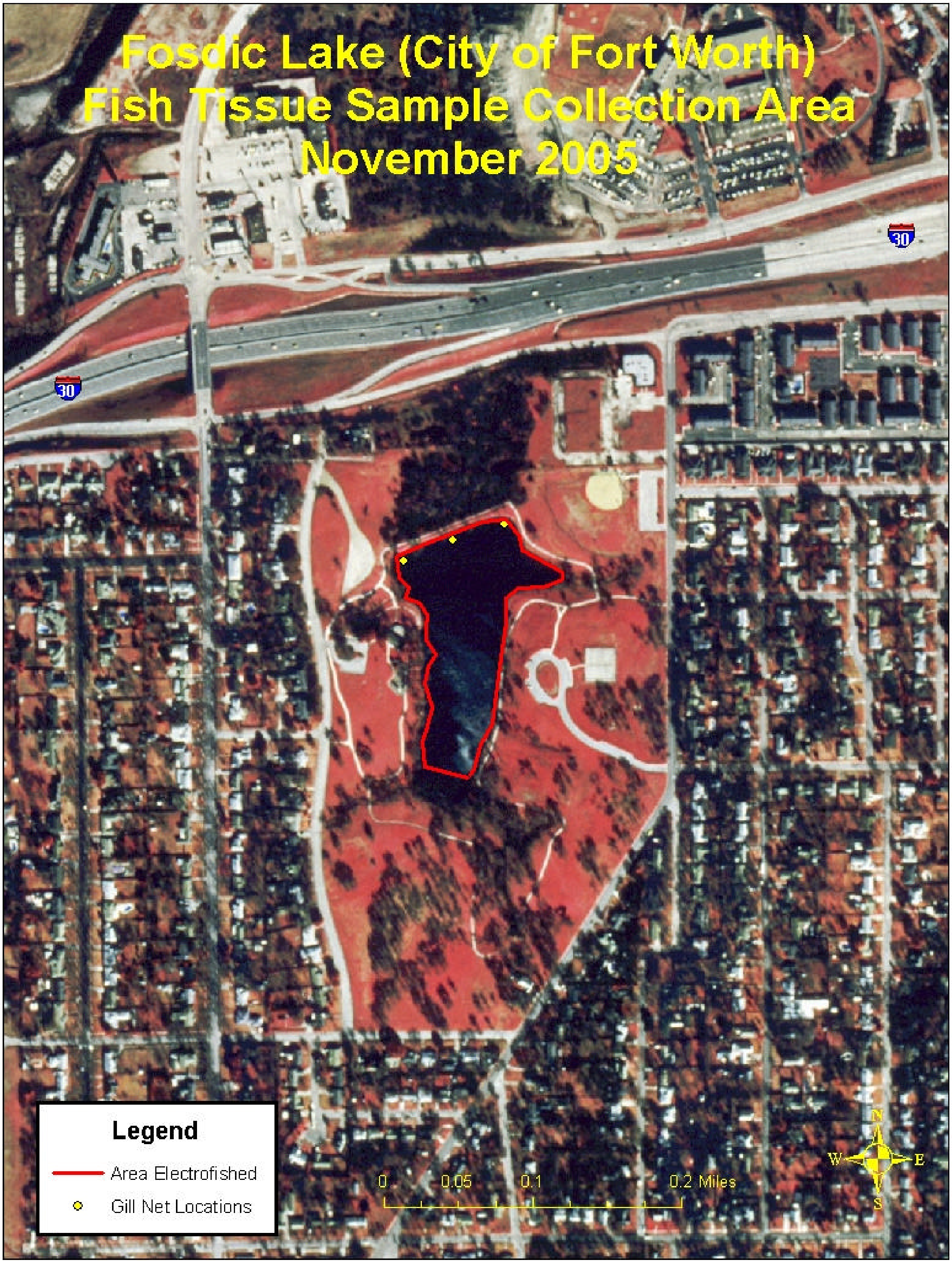
3. That the DSHS continues to monitor fish from Fosdic Lake for PCBs and for other contaminants.

PUBLIC HEALTH ACTION PLAN

Communication of possession bans, consumption advisories – or the removal of either – to the public is essential. The DSHS publishes fish consumption advisories and bans in a booklet available to the public through the SALG. To receive the booklet readers may contact the SALG at 1-512-834-6757.[40] For the most current information about advisories and bans or the repeal or modification these materials, one may also access the SALG's Web site at http://www.dshs.state.tx.us/seafood. The SALG regularly updates this Web site with current information. The DSHS also provides the U.S. Environmental Protection Agency (http://epa.gov/waterscience/fish/advisories/), the Texas Commission on Environmental Quality (TCEQ; http://www.tceq.state.tx.us), and the Texas Parks and Wildlife Department (TPWD; http://www.tpwd.state.tx.us) with information on all consumption advisories, possession bans, or rescinded or modified advisories or bans. Each year, the TPWD informs the fishing and hunting public of consumption advisories and fishing bans on its Web site (follow the internal links from the main TPWD site) and in an official hunting and fishing regulations booklet available at many state parks and at all establishments selling Texas hunting or fishing licenses.[41]

Readers may direct questions about the scientific information or recommendations in this risk characterization to the Seafood and Aquatic Life Group (512-834-6757) or they may find some information at the SALG's Web site (http://www.dshs.state.tx.us/seafood). Secondarily, one may address inquiries to the Environmental and Injury Epidemiology and Toxicology Branch of the Department of State Health Services (512-458-7269). The EPA's IRIS Web site (http://www.epa.gov/iris/) contains much information on environmental contaminants found in food and environmental media. The Agency for Toxic Substances and Disease Registry (ATSDR), Division of Toxicology also publishes information that may be requested from the agency's toll-free number (888-42-ATSDR – 888-422-8737). The ATSDR Web site (http://www.atsdr.cde.gov) supplies brief information via ToxFAQs.® ToxFAQs® are available in either English (http://www.atsdr.cdc.gov/toxfaq.html) or Spanish (http://www.atsdr.cdc.gov/es/toxfaqs/es _toxfaqs.html). The ATSDR also publishes more in-depth reviews of many toxic substances as *Toxicological Profiles.* To request copies of ToxProfiles™ CD-ROM, PHS, or ToxFAQs™ readers may telephone 1-800-CDC-INFO (800-232-4636) or email their requests to cdcinfo@cdc.gov. Many Toxicological Profiles are also available for free downloading at ATSDR's Web site.

FIGURE 1. Fosdic Lake Map 2005



TABLES

Table 1. Fish Samples Collected from Fosdic Lake in November 2005. Species, Length, and Weight were Recorded for Each Collected Sample.

Sample Number	Species	Length (mm)	Weight (g)
FOS1	Largemouth Bass	370	841
FOS2	Largemouth Bass	405	925
FOS3	Largemouth Bass	356	644
FOS4	Largemouth Bass	343	687
FOS5	Largemouth Bass	415	1020
FOS6	Largemouth Bass	403	868
FOS7	Largemouth Bass	370	754
FOS8	Largemouth Bass	409	838
FOS9	Largemouth Bass	358	701
FOS10	Common Carp	560	2508

Table 2a. Arsenic (mg/kg) Measured in Fish Collected in 2005 from Fosdic Lake.

<table>
<tr><th>Species</th><th># Detected/ # Sampled</th><th>Total Arsenic Mean Concentration ± S.D. (Min-Max)</th><th>Inorganic Arsenic Mean Concentration[a]</th><th>Health Assessment Comparison Value (mg/kg)[b]</th><th>Basis for Comparison Value</th></tr>
<tr><td>Largemouth Bass</td><td>9/9</td><td>0.064 ± 0.026
(0.035-0.111)</td><td>0.006</td><td rowspan="3">0.7
0.362</td><td rowspan="3">EPA chronic oral RfD for Inorganic arsenic: 0.0003 mg/kg–day
EPA oral slope factor for inorganic arsenic: 1.5 per mg/kg–day</td></tr>
<tr><td>Common Carp</td><td>1/1</td><td>0.067</td><td>0.007</td></tr>
<tr><td>All Fish Combined</td><td>10/10</td><td>0.064 ± 0.024
(0.035-0.111)</td><td>0.006</td></tr>
</table>

[a] Most arsenic in fish and shellfish occurs as organic arsenic, considered virtually nontoxic. For risk assessment calculations, DSHS assumes that total arsenic is composed of 10% inorganic arsenic in fish and shellfish tissues

[b] Derived from the MRL or RfD for non-carcinogens or the USEPA slope factor for carcinogens; assumes a body weight of 70 kg, and a consumption rate of 30 grams per day, and assumes a 30-year exposure period for carcinogens and an excess lifetime cancer risk of 1x10^{-4}.

Table 2b. Inorganic Contaminants (mg/kg) in Fish Collected in 2005 from Fosdic Lake.				
Contaminant	**# Detected/ # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Cadmium				
Largemouth Bass	8/9	BDL[c]	0.47	ATSDR chronic oral MRL: 0.0002 mg/kg–day
Common Carp	1/1	BDL		
All Fish Combined	9/10	BDL		
Copper				
Largemouth Bass	9/9	0.151 ± 0.071 (0.102-0.334)	333	National Academy of Science Upper Limit: 0.143 mg/kg–day
Common Carp	1/1	1.270		
All Fish Combined	10/10	0.263 ± 0.360 (0.102-1.270)		
Lead				
Largemouth Bass	1/9	BDL	0.6	EPA IEUBKwin[c]
Common Carp	0/1	ND[d]		
All Fish Combined	1/10	BDL		
Mercury				
Largemouth Bass	9/9	0.253 ± 0.169 (0.107-0.548)	0.7	ATSDR chronic oral MRL: 0.0003 mg/kg–day
Common Carp	1/1	BDL		
All Fish Combined	10/10	0.230 ± 0.174 (BDL-0.548)		

[c] BDL: "Below Detection Limit" – Concentrations were reported as less than the laboratory's method detection limit ("J" values). In some instances, a "J" value was used to denote the discernable presence in a sample of a contaminant at concentrations estimated as different from the sample blank, while at other times, a "<" followed by the laboratory's MDL was utilized to note that a contaminant was detected below the detection limit, but was not quantified.

[d] ND: "Not Detected" was used to indicate that a compound was not present in a sample at a level greater than the MDL.

Table 2c. Inorganic Contaminants (mg/kg) in Fish Collected in 2005 from Fosdic Lake.

Contaminant	# Detected/ # Sampled	Mean Concentration ± S.D. (Min-Max)	Health Assessment Comparison Value (mg/kg)	Basis for Comparison Value
Selenium				
Largemouth Bass	9/9	0.153± 0.033 (0.119-0.221)	6	EPA chronic oral RfD: 0 .005 mg/kg–day ATSDR chronic oral MRL: 0.005 mg/kg–day NAS UL: 0.400 mg/day (0.005 mg/kg–day) RfD or MRL/2: (0.005 mg/kg –day/2= 0.0025 mg/kg–day) to account for other sources of selenium in the diet
Common Carp	1/1	0.251		
All Fish Combined	10/10	0.163± 0.044 (0.119-0.251)		
Zinc				
Largemouth Bass	9/9	5.349± 1.688 (4.007-9.345)	700	EPA chronic oral RfD: 0.3 mg/kg–day
Common Carp	1/1	15.079		
All Fish Combined	10/10	6.322± 3.464 (4.007-15.079)		

Table 3. Pesticides (mg/kg) and Polychlorinated Biphenyls (PCBs – mg/kg) in Fish collected in 2005 from Fosdic Lake.

Contaminant	# Detected/ # Sampled	Mean Concentration ± S.D. (Min-Max)	Health Assessment Comparison Value (mg/kg)	Basis for Comparison Value
4,4'-DDE				
Largemouth Bass	9/9	0.007± 0.005 (BDL-0.014)	1.167	EPA chronic oral RfD: 0.5 .g/kg–day
Common Carp	1/1	0.043		
All Fish Combined	10/10	0.010± 0.012 (BDL-0.043)	1.578	EPA slope factor 0.34 per mg/kg–day
Chlordane				
Largemouth Bass	9/9	0.009± 0.006 (BDL-0.019)	1.167	EPA chronic oral RfD: 0.5 µg/kg–day
Common Carp	1/1	0.063		
All Fish Combined	10/10	0.014± 0.018 (BDL-0.063)	1.553	EPA slope factor 0.35 per mg/kg–day
PCBs				
Largemouth Bass	9/9	0.031± 0.013 (0.021-0.059)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Common Carp	1/1	**0.070**		
All Fish Combined	10/10	0.035± 0.017 (0.021-0.070)		

Table 4. Hazard quotients (HQ) for PCBs in fish Collected from Fosdic Lake in 2005. The table also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults. [e]

Species	Hazard Quotient	Meals per Week
Common carp	**1.50**	**0.6**
Largemouth bass	0.67	1.4
All Fish Combined	0.75	1.2

Table 5. Theoretical lifetime excess cancer risk calculated from projected consumption of each species of PCB-contaminated fish collected in 2005 from Fosdic Lake. The table also suggests weekly eight-ounce meal consumption rates for 70-kg adults who eat one or both fish species collected from Fosdic Lake. [e]

Species	Theoretical Lifetime Excess Cancer Risk		Meals per Week
	Risk	1 excess cancer per number of people exposed	
Common carp	2.6E-05	38,889	3.6
Largemouth bass	1.1E-05	87,814	8.1
All Fish Combined	1.3E-05	77,778	7.2

[e] DSHS assumes that children under the age of 12 years and/or those who weigh less than 35 kg eat 4-ounce meals.

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